Rocky Mountains Southwest Great Plains

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Feasibility of Collecting Firewood Blocks with a Small Skyline

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Firewood collection from the Nation's forests has been increasing rapidly . Additional areas are needed for firewood collections in the future. Areas above and adjacent to roads but having slopes too steep for collectors to either hand-carry or drag wood have potential if an easier method of moving wood were available. A single-span skyline made from No. 9 wire and other materials from a farm and ranch store has potential for moving firewood down slopes by gravity. A mathematical model was used initially to calculate maximum spans that would not exceed tension and deflection limits. Subsequent field testing showed that the predicted spans were quite conservative.

Keywords: Firewood, wire skyline, skidding, forest products

Introduction

Firewood collection from the Nation's forests has been increasing rapidly. In many of the accessible areas, the dead material left by insect attacks, wildfire, and old timber sales has been used up. Presently accessible live trees are being cut to supply firewood. The firewood program varies from forest to forest and from area to area within a forest, depending on the availability of firewood.

Additional areas are needed for firewood collections in the future. Areas above and adjacent to roads but having slopes too steep for collectors to either hand-carry or drag wood have potential if an easier method of moving wood were available. One possible method would be a simple, single-span skyline system that is scaled down in size and cost from those used in sawlog operations. Such a system would eliminate possible soil erosion caused by wood being dragged on the ground.

The use of a small skyline to transport firewood down steep slopes to a roadside was reported by Joseph and Stowers (1981). A sling consisting of a pulley and bracket carried wood down a polyester rope. The rope was tied to trees at the top and bottom of the hill, with the tension in the rope being applied with a come-along. The use of a wire skyline for transporting small logs in the Philippines was described by Tolentino (1981). The main components of the system are a wire, wire grip, wire tensioner, and an expendable load carrier. The design and use of large, cable skyline systems for harvesting sawlog size materials has been reported by Carson (1975, 1976, and 1977), Carson and Mann (1970), Lysons and Mann (1967), and Perkins et al. (1969). However, no specific literature was found on the engineering aspects of small skylines to move firewood blocks weighing from 20 to 50 pounds.

The ultimate purpose of this research is to increase the total net benefits from firewood collecting by making more wood available, reducing ecological damage, and reducing travel time and costs to more distant sites. The

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question that concerns a firewood collector is, "How far can I reach with a small skyline wire using gravitational force to move wood down steep slopes?" Specific objectives of this study were to (1) determine feasibility of using skylines to move firewood blocks of different weights down different slopes by gravity without exceeding tension and deflection limits, and (2) specify materials and costs of such skylines.

Methods

The first step in developing a skyline design was to analyze the effects of firewood block weights and slopes of the land upon the maximum potential spans of a single span skyline.

A mathematical model of a cable hanging in a catenary curve and an accompanying computer program developed by Perkins et al. (1969) were used to calculate these skyline spans. The skyline span and load relationships depend on the following:

1. Elevation difference between upper and lower ends of the skyline,
2. Horizontal distance between upper and lower ends of the skyline,
3. Deflection of the skyline, and
4. Strength and weight of the skyline wire.

Two types of skylines were modeled and tested, one with 1/8-inch wire rope with a breaking strength of 2,000 pounds and a second with No. 9 wire estimated at approximately 1,000 pounds. The allowable design tension load and deflection of the skyline assumed in this study were 667 pounds and 2 feet, respectively. The weight of the wire rope was 0.029 pounds and of the No. 9 wire 0.058 pounds per linear foot. A deflection of 2 feet was selected to allow a ground clearance of 2 feet for a 12-inch-diameter firewood block sliding down a uniform slope. The skyline was assumed to be attached to both the lower and upper spar tree at 5 feet above the ground. Five feet would probably be the maximum height reachable for a person to attach the skyline wire to spar trees or hang a firewood block on to the skyline without a ladder.

The maximum allowable skyline lengths to slide firewood blocks of different weights down different slopes were computed (table 1). The length to slide a 30-pound

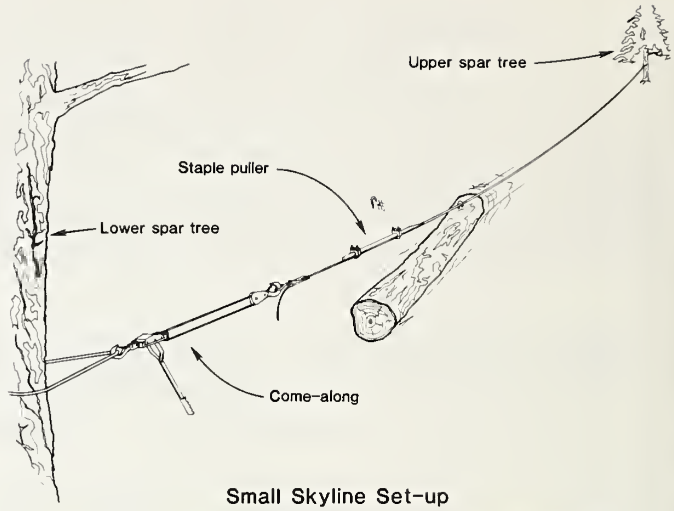

Figure 1.—Skyline stretched between two spar trees.

block down a slope of 20% would be 153 feet. However, if more deflection due to less initial tensioning of the wire were allowed, then a skyline length greater than 153 feet or a block weight greater than 30 pounds could be slid; but the relation of the variables expressed by the model must be maintained. Initial tightening of the wire is important. The wire can be overtightened to the extent it will break with any block load. Additional deflection may however prevent the block from sliding the entire length of the skyline by gravity.

The test skylines consisted of wires stretched between two trees (fig. 1). One end of the skyline was attached to either the upper or lower spar tree with a nylon rope and a quick-release wire grip (fig. 2). The other end of the skyline wire was attached to the other spar tree with either a boat-trailer winch or a come-along winch that applied tension to the skyline (figs. 3, 4). The skyline wire was attached to the winch cable by means of wire thimbles and clips and a chain link (fig. 5). Initial tensioning of 667 pounds was established by stapling a firewood block of maximum permitted weight (table 1) to the midspan of a slack wire. The wire was then tightened until the deflection at midspan was 2 feet. The deflection was determined by measuring the vertical distance between the top of the block and a monofilament fishing line stretched tightly between the spar trees (fig. 6). Two fencing staples with one prong shortened

Table 1.—Calculated maximum skyline spans to slide firewood blocks of different weights down different slopes with wire or wire rope skyline, feet.[1]

Skyline type	Firewood block weight, lbs.	Slopes, % 20	Slopes, % 40
		-- maximum skyline span --	
No. 9 wire	30	153	151
	50	92	97
1/8-inch wire rope	30	163	162
	50	102	97

[1]*The maximum skyline spans are calculated on the basis of midspan deflection of 2 feet and allowable tension load of 667 pounds.*

with a wire cutter were driven into the firewood blocks (fig. 7). The blocks were hooked on to the skyline and slid by gravity to the lower spar tree (figs. 8, 9). The blocks were prevented from hitting the lower spar tree by either attaching tires to the tree or attaching a staple-pulling device to the skyline (figs. 10, 11).

Results and Discussion

Eight different combinations of skyline type, firewood block weight, and slopes of land were initially field tested at the Fraser Experimental Forest (table 2). The tests included No. 9 wire and 1/8-inch wire rope skylines, 30- and 50-pound firewood blocks, and 20% and 40% slopes. Each skyline was tested with 10 firewood blocks being slid down the skyline. The spans of the skylines tested were determined by the location of the available spar trees. Consequently the test spans were slightly longer or shorter than the calculated maximum skyline span shown in table 1. There were no equipment failures for any of the 8 skylines tested. However, the firewood blocks did not slide completely down to the lower spar tree in all cases. The blocks generally stopped 10 to 40 feet before the lower spar tree when the 1/8-inch cable was tested on 20% slopes. On the 20% slopes, the blocks slid completely to the spar tree or the kick-off device with No. 9 wire.

The reliability of the skyline design method in predicting maximum potential span was evaluated using (1) test skyline spans that were longer than the calculated maximum spans, (2) 20-pound blocks, (3) No. 9 wire, and (4) a 2-foot midspan deflection. The slopes and skyline spans predicted and tested were as follows:

Slopes (percent)	Skyline spans: Predicted maximum	Skyline spans: Field test
	(length, feet)	
20	204	242
30	198	255

Figure 2.—No. 9 skyline wire attached to spar tree with quick-release wire grip and 1/2-inch nylon rope.

Figure 4.—Tightening skyline with come-along attached to quick-release wire grip.

Figure 3.—Boat-trailer winch bolted to 2 by 4 inch by 8 foot wooden member tied to spar tree.

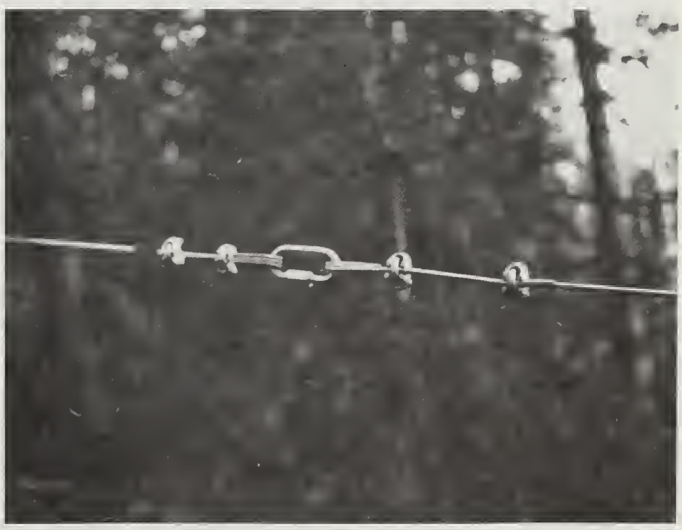

Figure 5.—Connection of winch cable to skyline wire with wire thimbles and clips and a chain link.

Figure 6.—Measuring deflection of skyline at midspan.

Figure 9.—Firewood block sliding down skyline. Note the deflection in the skyline at the firewood block location.

Figure 7.—Driving fencing staples near ends of firewood block. Note that one of the prongs of the staples has been shortened.

Figure 10.—Tires tied to lower spar tree to remove firewood block from skyline and protect tree from impact.

Figure 8.—Hooking firewood block onto skyline wire.

Figure 11.—Staple puller was made from a 3/8 by 9 inch iron rod attached to skyline wire with two cable clips.

Table 2.—Skyline types and spans tested with different firewood block weights and land slopes, in feet.

Skyline type	Firewood block weight, lbs.	No. of blocks	Slopes, % 20	40
			- skyline	spans -
No. 9 wire	30	10	159	160
	50	10	100	104
1/8-inch wire rope	30	10	159	160
	50	10	100	104

The skyline span tested on the 20% slope was 19% longer and the span tested on the 30% slope was 29% longer than the calculated maximum spans. These skylines did not fail when each was tested with 15 blocks. On 20% slopes when the No. 9 wire was wiped with an oil rag prior to the test, all blocks slid completely down to lower spar tree.

The model is conservative in estimating the maximum allowable spans probably because a "lower" working strength of 667 pounds was used instead of a higher value nearer to 1,000 pounds for the estimated breaking strength of No. 9 wire. The working strength allowed for protection against failures.

A listing of components and approximate costs for skylines comparable to those tested in the the study follows:

Component	Cost (dollars)
300 feet of galvanized No. 9 merchant wire	7.50
2-ton come-along winch	15.00
1 1,500-lb. quick release wire grip	7.50
1 staple-pulling device	2.50
2 1/8-inch wire thimbles	1.50
4 1/8-inch wire clips	2.50
30 feet of 3/8-inch nylon rope	7.00
2 chain links	6.00
5 lbs. of 2-inch staples	3.00
Total	52.50

Conclusions

This study has shown that a single-span skyline made from No. 9 wire and other materials available from a farm and ranch store has potential for moving firewood down slopes of 20% and greater. The skyline can be fabricated with handtools commonly found in a home workshop. The skyline equipment can be hand-carried to the skidding area and erected by two people in about 1 hour after the spar trees have been selected and the skyline path cleared. Firewood blocks weighing 20 pounds or less can be lifted and attached to the skyline by one person. The durability of the skylines was not fully tested because of limited opportunities for application. None of the skyline wires showed any significant visible wear. The staples holding the firewood block to the wire rope skyline did, however, show wear while the staples holding the blocks to the No. 9 wire did not show wear. There must not be any loops in the line when initial tension is being applied; otherwise the line will kink and fail.

Important safety practices with the skyline are (1) standing to the side when tightening the skyline with a winch; and (2) standing at least 50 feet from where the firewood blocks are released near the lower spar tree.

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Rocky Mountain Forest and Range Experiment Station

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